DEEP-WATER FORMATION PROCESSES IN THE ADRIATIC SEA: SIMULATIONS OF THE INTERANNUAL VARIABILITY

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Abstract

The sensitivity of the water mass formation processes in the Adriatic Sea to inter-annual atmospheric forcing is investigated using the POM model for a period of 21 years (1979-1999) and it is found to be important in agreement with observations. During severe winters deep convection occurs in the Southern Adriatic Pit (SAP) and DWF rates can be almost 3 times larger than climatology. The production of the deep water is mostly associated to events of enhanced buoyancy loss and not to the mean winter fields.

Keywords: Adriatic Sea, deep-water formation, inter-annual variability

Introduction

The Adriatic Sea is the area where the deep waters of the Eastern Mediterranean are formed. Climatological model simulations showed that the major portion of the Adriatic Deep Water (ADW) exiting through the Otranto Strait is formed in the Southern Adriatic Pit, while a smaller contribution originates in the Northern Adriatic (1) and the annual DWF rates of the basin is 0.34Sv (2). Observations (3,4) show that the intensity of vertical convection in the Southern Adriatic varies greatly on an inter-annual basis. The scope of this study is to simulate and estimate the inter-annual variability of the deep-water formation process in Adriatic in terms of deep-water formation sites, rates and characteristics and investigate the role of the atmospheric forcing.

Model set up

This study is performed using the Princeton Ocean Model (POM) with a 10km horizontal grid and 20 sigma levels in the vertical. The model is initialized with MODB data set and the atmospheric forcing is provided from 6h-ECMWF re-analysis and analysis data for a period of 21 years (1979-1999). All major rivers of the basin have been parameterized in it and the heat fluxes are computed with an air-sea interaction scheme that uses the model produced sea surface temperature (SST).

Results and discussion

The analysis of the atmospheric data of the period under examination revealed a stronger inter-annual variability during winter than in summer both in the heat and fresh water budget components which in turn induces a strong inter-annual signal in the deep-water formation process. The spatial pattern and the intensity of the buoyancy losses within the Adriatic basin vary from winter to winter. Thus there are different contributions of the Northern Adriatic Deep Water (NADW) and the Southern Adriatic Deep Water (SADW) in the overall production of ADW that exits through the Otranto Strait into the Ionian Sea from year to year. The inter-annual variability in the duration of the DWF process and the DWF sites and rates seem to be highly determined by the inter-annual variability of the prevailing atmospheric conditions. The simulations show that during the severe winters of the years 1986-87, 1991-92 and 1992-93 deep convection occurred in the Southern Adriatic, while during the mild winters of the years 1989-90, 1993-94, 1996-97 the mixed layer depth in the SAP was shallow. Moreover years with similar mean buoyancy winter losses have different mixed layer depths and different deep-water characteristics in the SAP. The mixed layer depth seems to be determined mostly by the high frequency events of cold and dry winds rather than the mean buoyancy loss of the specific year. Finally the amount of deep-water that outflows through the Otranto strait follows the intensity of the deep-water formation process inside the Adriatic basin.

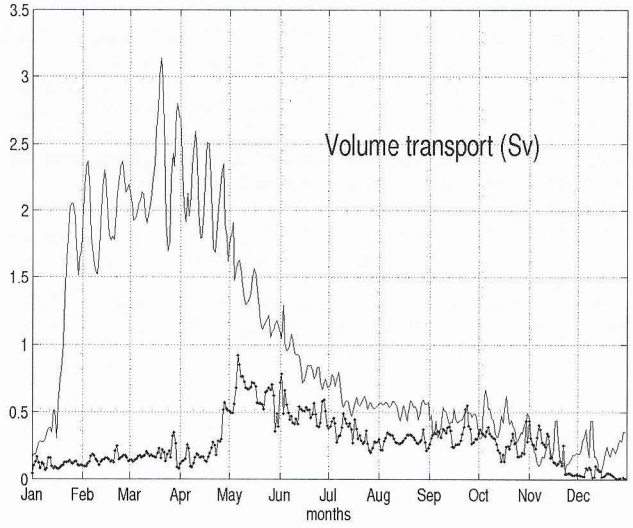

Fig. 1. Time series of the Adriatic Deep-Water outflow (sigma theta greater than 29.15) for the years 1992 (solid line) and 1997 (dotted line) with mean annual ADW rates of 0.99Sv for the year 1992 and 0.27Sv for the year 1997.

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